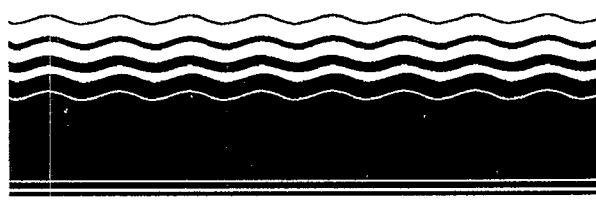




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Emerging Technology Bulletin

Volatile Organic Compound Removal from Air Streams by Membranes Separation

Membrane Technology and Research, Inc.

Technology Description: This membrane separation technology developed by Membrane Technology and Research (MTR), Incorporated, is designed to remove volatile organic compounds (VOCs) from contaminated air streams. In the process, organic vapor-laden air contacts one side of a membrane that is permeable to organic vapors but relatively impermeable to air. A partial vacuum, applied to the other side, draws the organic vapor through the membrane. The permeate vapor is then compressed and condensed to recover the organic fraction. The purified airstream is removed on the feed side.

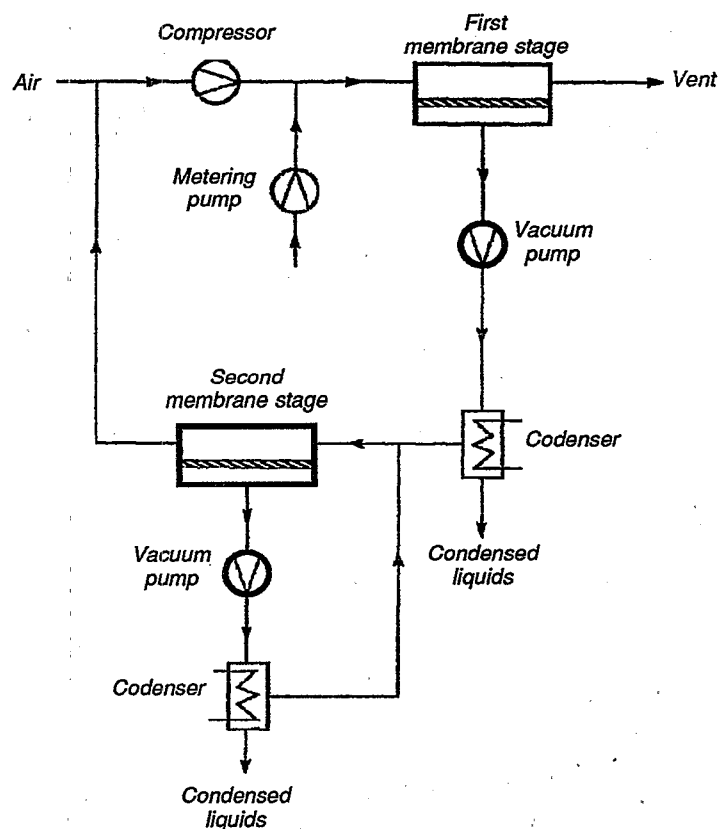
The MTR membrane unit is a spirally-wound module comprised of a perforated pipe bound within the wound membrane and spacers. Feed gas flows between the membrane leaves, with the preferentially permeable component spiralling inward to connect in the central permeate collection pipe. The remainder of the feed flows across the membrane surface and exits as the residue.

In the membrane separation system pilot unit, VOCs in a compressed air stream enter the first of two membrane stages (Figure 1). This first stage concentrates most of the VOCs into the permeate stream. The permeate is recompressed and condensed, normally producing only water from the atmosphere. The bleed stream leaving the condenser enters the second membrane stage reducing the VOC content to a concentration close to that of the first stage. The permeate from this stage is concentrated enough with VOCs to allow for its condensation. The bleed stream from this condenser is recirculated back to the second stage membrane unit. In its entirety, the system separates the VOC-laden air stream into a VOC-depleted stream and condensed liquid VOC.

Waste Applicability: The MTR membrane separation process is geared towards removing VOCs from air streams commonly produced in the vacuum extraction of VOCs from soils or by the air stripping VOCs from contaminated surface water, as well as air streams from manufacturing operations using solvents. The system produces the recovered VOCs as a liquid from the final condenser. The process adapts to meet capacity and separation requirements of a particular situation by arranging the membrane modules in parallel and/or series flow.

Test Results: The MTR membrane pilot system was operated with perchloroethylene (C_2Cl_4 or Perc) and with a mixture of hexane isomers and i-octane as typical contaminants be used in the system to evaluate the system performance. Nine runs with

Figure 1. Two-stage membrane process.



the Perc were used to determine the effects of inlet flow rate and inlet concentration. Based on varying the inlet concentration from 43 to 99 parts per million (ppmv) the overall perchloroethylene removal is approximately 90% and is relatively insensitive to the entering concentration. The flow rate was varied from 24.1 to 27.6 scfm along with the changing concentration, but the small range over which it was varied showed no statistically determinable effect. The system was compared to another study in which inlet flowrate was an isolated variable. This other study showed about a 17% decrease in the removal efficiency for an increase from 7 to 28 scfm. Nine runs with varying permeate pressures (i.e., vacuum) on each of the stages were also run with Perc.



The data from these runs showed that it is advantageous to operate a membrane system at the lowest attainable permeate pressure. Also determined, the selectivity of the MTR vapor separation membranes increases significantly with decreasing temperature for most organic vapors

Six runs of the hexane isomer and i-octane mixture were carried out, showing that typically 88 to 91% of these hydrocarbons were removed even with an inlet concentration varied between 350 and 1540 ppm (Table 1).

Thirteen VaporSep systems are now operating on industrial process streams to recover a variety of VOCs, including CFCs,

HCFCs, and vinyl chloride monomer. In partnership with a supplier of hospital sterilizer equipment, MTR has applied the technology to the treatment of sterilizer emissions. Another system is being demonstrated on an off-gas stream containing carbon tetrachloride and chloroform generated by a soil-venting operation.

A paper describing VaporSep technology and its applications is available.

Table 1. Two-Stage Treatment of Hexanes and i-Octane

Feed rate (scfm)	Feed (ppm)		Residue (ppm)		Total Hydrocarbon removal(%)
	Hexane	i-Octane	Hexane	i-Octane	
25.8	890	650	74	65	91
29.7	400	250	46	30	88
30.8	660	520	74	59	89
27.4	180	170	20	20	89
31.4	640	480	78	58	88
29.3	350	230	37	28	89

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